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FINAL TASK SPECIFIC PLAN BUILDING 680 SCOPING SURVEY NAS WILLOW GROVE PA
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TETRA TECH INC

Final

Task Specific Plan
Building 680
Scoping Survey

Naval Air Station Joint Reserve Base
Willow Grove
Horsham, Pennsylvania

October 2014

Prepared for:

Department of the Navy
Base Realignment and Closure
Program Management Office East
Philadelphia, Pennsylvania

Prepared by:

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FINAL

TASK SPECIFIC PLAN
BUILDING 680
SCOPING SURVEY

NAVAL AIR STATION JOINT RESERVE BASE
WILLOW GROVE
HORSHAM, PENNSYLVANIA

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REVIEW AND APPROVAL

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ACRONYMS AND ABBREVIATIONS

α	Alpha
β	Beta
ε_i	Instrument efficiency
ε_s	Contaminated surface efficiency
B	Background count rate
b_i	Number of background counts in scan time interval
d'	Index of sensitivity
E	Detector efficiency
G	Source activity
i	Scan or observation interval
ρ or P	Probability
p	Surveyor efficiency factor
R_B	Background count rate
t	Time interval of detector over source
T_B	Background counting time
T_{S+B}	Sample counting time
W_A	Area of the detector window
$Z_{1-\alpha}$	Type I decision error level
$Z_{1-\beta}$	Type II decision error level
AIMD	Aircraft Intermediate Maintenance Division
ASW	Anti-Submarine Warfare
cm	Centimeter
cm2	Square centimeter
cm/sec	Centimeter per second
cpm	Count per minute
Co-60	Cobalt 60
Cs-137	Cesium 137
dpm	Disintegration per minute
DFW	Definable features of work
DU	Depleted Uranium
ft^2	Square feet
H-3	Tritium
HASP	Health and Safety Plan
HRA	Historical Radiological Assessment

IBIS	In-Flight Blade Inspection Systems
inch/sec	Inch per second
JRB	Joint Reserve Base
LBGR	Lower bound of the gray region
MAG	Marine Air Group
MARSSIM	Multi-Agency Radiation Survey and Site Investigation Manual
MDC	Minimum detectable concentration
MDCR	Minimum detectable count rate
min	Minute
N	Number of data points
NAS	Naval Air Station
NRC	Nuclear Regulatory Commission
Pa-234m	Protactinium 234 metastable
PSPC	Position sensitive proportional counter
RASO	Radiological Affairs Support Office
ROC	Radionuclides of concern
SCM	Surface contamination monitor
sec	Second
SIMS	Survey Information Management System
SOP	Standard operating procedure
Sr-90	Strontium 90
Th-232	Thorium 232
Th-234	Thorium 234
TSP	Task specific plan
U-238	Uranium 238

1.0 INTRODUCTION

This task specific plan (TSP) provides task-specific details for the scoping survey at Building 680 at the Willow Grove Naval Air Station (NAS) Joint Reserve Base (JRB) in Willow Grove, Pennsylvania. The survey will be conducted in accordance with the general approach and methodologies that are given in the Basewide Radiological Management Plan at Naval Air Station Joint Reserve Base, Willow Grove (TetraTech 2014a) and standard operating procedures (SOP). The surveys will conform to the requirements of the Health and Safety Plan (HASP) Naval Air Station Joint Reserve Base, Willow Grove (TetraTech 2014b) prepared for the survey program. No exceptions to the Management Plan, SOPs, and HASP are noted.

.1.1 SITE DESCRIPTION AND HISTORICAL SUMMARY

Building 680 was the Marine Aircraft Hangar (Figure 1). The steel-framed building features two sets of telescoping sliding doors on the air side. The building was constructed in 1989 and is approximately 113,600 square feet. A drawing from 1987 for this building shows the operational portions of the building to be aviator equipment shop, electrical/instrumentation shop, armament shop/armory, air frames shop, and operations training. A 1996 survey found asbestos in this building (HRA-0188).

Building 680, which was built on the footprint of Building 61 (Heavy Equipment Shed), housed Marine Air Group (MAG) 49 from 1989 to 2011. The six MAG 49 squadrons that occupied this building were responsible for the operation and maintenance of heavy helicopters and attack aircraft known to contain radioactive materials. Aircraft that were potentially housed and repaired in this building between 1989 and 2011 and their associated radioisotopes are listed in Table 6-1 of the Historical Radiological Assessment (HRA)(TetraTech 2013). Table 4-2 of the HRA (TetraTech 2013) also lists aircraft components containing radioactive material. Examples of radioactive materials possibly used in this building were DU counterweights, ice detector probes, engine ignition exciters, In-Flight Blade Inspection Systems (IBIS), and drogue lights. Additionally, ice detector probes were stored in this building for disposal (HRA-0129). The MAG 49 Ordnance Division did not handle live ordnance (HRA-0024). The areas within Building 680 that would have the potential for maintenance activities on equipment containing radioactive material are the main hangar bay and the electronics repair shops in rooms 107 and 121. The impacted area consisting of the hangar bay and the two shops is a total of 30,007 square feet or 2791 square meters. During the years of use for this building, aircraft would not have contained radioluminescent instrumentation containing Ra-226. The specific radionuclides of concern (ROC) identified in the Historical Radiological Assessment (HRA) (TetraTech 2013) are tritium (H-3), cobalt 60 (Co-60), strontium 90 (Sr-90) cesium 137 (Cs-137), thorium 232 (Th-232) and depleted uranium (DU).

2.0 SURVEY DESCRIPTION

This survey is being performed to assess if residual activity is above the established release criteria, as defined in Table 6-1 of the Management Plan (TetraTech 2014a). Surveys of the facility will be performed to determine the existence of radionuclides associated with the storage of aircraft parts, self-illuminating instruments and markers. Surveys will be performed for the presence of Co-60, Sr-90, Cs-137, Th-232 and DU, which consists of uranium 238 (U-238) and short lived progeny.

Alpha surveys will be performed to determine compliance with release criteria for Th-232. Areas that exceed the investigation criteria based on the activity level determined by the SCM will be investigated.

DU consists of U-238 and short lived progeny thorium 234 (Th-234) and protactinium 234m (Pa-234m). Although U-238 decays by alpha emission, both Th-234 and Pa-234m decay by beta emission. Since both Th-230 and Pa-234m are short lived, the three isotopes are in secular equilibrium. Therefore, measuring the beta emission from a surface can determine compliance with the U-238 release criteria. In fact, the preferred method of determining the presence of DU on surfaces is through the use of beta scans and direct measurements.

Beta surveys will be performed to show compliance with Co-60, Sr-90, Cs-137 and DU. Co-60 emits relatively low energy betas compared to the other ROCs. The low energy beta results in a low instrument efficiency and a low surface efficiency. The total efficiency of the SCM for Co-60 will be much less than that for either Cs-137 or DU (U-238 and short lived progeny) which have the same release criteria. Therefore, Co-60 will be more limiting than either Cs-137 or DU. However, the total efficiency for Co-60 will be more than $1/5^{th}$ of the efficiency for Sr-90. Since the ratio of the release criteria of Co-60 to Sr-90 as identified in Section 2.2, is 5 to 1, a single beta survey to determine compliance with the Sr-90 release criteria will show compliance with the Co-60 criteria as well. Therefore, beta surveys will be conducted to show compliance with the most limiting isotope Sr-90. Areas that exceed the release criteria for Sr-90 will be investigated.

Swipe surveys will be obtained at predetermined locations. Swipes will be analyzed onsite for both alpha and beta emitting radionuclides. Wet swipe surveys will be performed for tritium.

100% gamma walkover surveys will be performed in accordance with SUR-022, *Gamma Walkover Surveys*, in each survey unit to provide additional assurance that no hidden sources of radioactivity exist in the survey unit area.

2.1 SURVEY PREPARATION AND ACTIVITIES

Areas within Building 680 that have flooring material that has been installed since the possible use of radioactive materials will have the flooring removed to expose the concrete surface to conduct the required scan and fixed measurement surveys. Materials containing asbestos will be removed by a certified asbestos abatement contractor. Materials (tile, carpet, cabinets, shelving) will be surveyed for release in accordance with SOP-012, *Release of Materials and Equipment.* Materials with radioactivity above the limits specified in Table 6-1 of the Management Plan will be packaged for storage and subsequent disposal. Materials that cannot be surveyed due to physical size or porosity will be randomly checked for radioactivity and maintained on site until completion of the building survey. If the Building 680 scoping survey and the random surveying of the material do not identify any radioactivity above background, the material will be disposed of as non-radioactive waste

Interior walls in Building 680 will not be included in the areas to be surveyed. Building 680 will be surveyed as a Class 3 area. Class 3 areas are not expected to contain residual radioactivity. However, due to the nature of the materials containing radioactivity used, maintained or stored in the impacted areas, the higher probability of residual radioactivity is on the floor surfaces. If any radioactivity greater than the release criteria is detected, reclassification of the area will be evaluated and the wall surfaces will be considered.

Survey area preparation activities will be performed under radiological controls established in the SOPs. A listing of applicable SOPs for both preparation and survey activities is provided in Table 1. Surveys conducted in support of area preparation activities can provide input into final reports, but will not be used to demonstrate compliance with the release criteria or determination for additional survey requirements.

2.2 Release Criteria

The building surface release criteria for Sr-90 and Th-232 is 1000 disintegrations per minute (dpm) per 100 square centimeters (cm^2) total activity, and for Co-60, Cs-137, U-238 it is 5,000 dpm/100 cm^2 (TetraTech 2014a). The removable contamination release criteria is one-fifth of the total activity limits (TetraTech 2014a). Tritium release criteria is based on removable activity of 1,000 dpm/100 cm^2 The limits for the specific radionuclides to be addressed in Building 680 are provided in Table 2. Alpha surveys will be performed to meet the criteria for Th-232. Beta surveys will be performed to meet the criteria for Co-60, Sr-90 Cs-137 and U-238.

2.3 Reference Area

The reference area will be selected with the concurrence of Navy Radiological Affairs Support Office (RASO). The reference areas for the Building 680 survey will consist of concrete floors The reference materials will be identified in on-site buildings that have no history of containing radioactive material. The reference area survey data will be obtained prior to final recording of surveys within Building 680 and will be included in the Building 680 survey report.

2.4 Investigation Levels

Investigation levels for the alpha and beta surveys will be equal to the release criteria in Section 2.2 for the more restrictive isotope of concern in each area to be surveyed. For gamma walkover surveys, areas exceeding 3 sigma (3σ) above the mean of the survey unit will be investigated. Investigations of alpha or beta surveys may consist of resurveys with longer count times, determination of background adequacy or other means to determine if compliance with release criteria is achieved. Gamma walkover survey investigations will consist of resurveys of the area in which the high reading was obtained to determine the source of the elevated reading or if the reading was a statistical anomaly since approximately 1 percent of all readings will exceed the 3σ value.

2.5 SURVEY UNITS AND CLASSIFICATION

Building 680 will be surveyed as Class 3, requiring a 25 percent survey of floor. The total floor area of the impacted area of the building is 30,007 square feet or 2,791 square meters. The building will be surveyed as four survey units. A layout drawing indicating building dimensions and survey unit locations is provided as Figure 2. Using a random start point, systematic data collection locations (N) will be laid out in a triangular grid pattern for the survey units using the computer process provided by Visual Sample Plan (DOE 2014). In some cases, the number of data collection locations may exceed N based on the random location of the start point. Locations for data collection are provided in Figures 3 through 6. Additional biased surveys may be performed and samples may be collected at accessible points of ventilation systems and drain entrances within the building.

2.6 ESTABLISHING THE NUMBER OF MEASUREMENTS

To determine the number of measurements, N, to be taken per survey unit when the contaminant is not present in background, Equation 5-3 of the Management Plan (TetraTech 2014a) is used:

$$N = \left(\frac{(Z_{1-\alpha} + Z_{1-\beta})^2}{4(Sign\rho - 0.5)^2} \right)(1.2)$$

Where:

N = Number of data points

$Z_{1-\alpha}$ = Type I decision error level, 1.645

$Z_{1-\beta}$ = Type II decision error level, 1.645

Sign ρ = random measurement probability, 0.945201

1.2 = 20 percent increase in number of samples over the minimum

The values used in the calculation are from Multi-Agency Radiation Survey and Site Investigation Manual (MARSSIM) guidance (Nuclear Regulatory Commission [NRC] 2000) and are based on a recommended value for the relative shift (Δ/σ) of 1.6 as discussed in Section 5.5.2.2 of MARSSIM (NRC 2000). Type I and Type II decision errors are based on 0.05 false negative and 0.05 false positive rates. The associated Z values are obtained from MARSSIM Table 5.2 (NRC 2000). The random measurement probability, Sign ρ, is from MARSSIM Table 5.4 (NRC 2000).

Using the defined values, the equation becomes:

$$N = \left(\frac{(1.645 + 1.645)^2}{4(0.945201 - 0.5)^2} \right)(1.2)$$

The calculation results in a value of N = 16.38328. Therefore, a minimum of 17 measurements will be obtained in each survey unit.

2.7 ALPHA AND BETA SCAN MEASUREMENTS

Scan measurements are performed to identify elevated areas of radioactivity within the survey unit. Alpha scans will be effective for identifying elevated concentrations of Th-232. Beta scans will be effective for identifying elevated concentrations of Co-60, Cs-137, Sr-90 or U-238. Twenty five percent of floor surfaces of the Class 3 survey unit will be scanned with the SCM. Based on the identified ROCs, the survey unit within Building 680 will be surveyed for alpha and beta activity. All scan surveys will be performed using the SCM. SCM scan surveys will be conducted in the dynamic, or "rolling" mode. Alpha scan measurements are discussed in Section 2.7.1. If adequate area is not available to the SCM in the dynamic mode, surveys may be supplemented by the SCM in the static mode discussed in Section 2.8.1. Beta scan measurements are discussed in Section 2.7.2. If adequate area is not available to the SCM in the dynamic mode, surveys may be supplemented by the SCM in the static mode discussed in Section 2.8.2

The SCM utilizes a gas flow position sensitive proportional counter (PSPC). The PSPC functions as any gas flow proportional counter, using P-10 as the counting gas. As in any proportional counter, voltage plateaus are established for the detection of alpha or alpha plus beta particles. High voltage appropriate for the type of particles to be detected is applied to the single anode wire which runs the length of the detector. The SCM computer compares the pulse heights of pulses sensed at each end of the anode wire and establishes the location on the anode wire where the pulsed was sensed. Although the available resolution is greater than 2,000 locations on the anode wire, the SCM computer will "bin" the data in 5 centimeters (cm) wide increments along the length of the wire.

The SCM can be operated in both a dynamic or "rolling" mode or a static or "corner" mode. In the dynamic mode, the system uses a direct current powered drive motor affixed to a cart which contains all electronics and computer hardware, and a detector (or two) is mounted to the front of the cart. The SCM's design focuses on the elimination of human errors associated with performing surveys of large areas. The system is designed such that surveys are performed at constant speed, the detector held at a set distance from the surface being surveyed, and survey data recorded automatically. In the dynamic mode, a precision wheel encoder is mounted to the cart axle to determine distance traveled by the cart. The encoder can measure to a small fraction of a centimeter and is used to trigger the computer to capture data for every 5 cm of travel of the SCM cart. The result is count data (counts) for every 5 cm "bin" for every 5 cm of travel, or a matrix of 25 cm^2 "pixels" of data. In the static mode, a preset time is applied to the collection of data from a stationary detector. Data is binned in a manner similar to the dynamic mode.

Data is transferred from the SCM to a processing station containing the Survey Information Management Systems (SIMS) software via removable media. SIMS software is used to “stitch” the individual strips of data to create a single survey of a survey unit or portion of a survey unit area. The data collected in 25 cm^2 “pixels” is summed with adjacent “pixels” in a manner that will result in the evaluation of every possible 100 cm^2 area. When determining activity, each 25 cm^2 “pixel” is 25 percent of four overlapping 100 cm^2 areas. This process ensures that small areas of activity above limits are not missed through grid registration errors.

2.7.1 Alpha Scan Measurements

The alpha emitting ROC is Th-232. To achieve the sensitivity to detect at the release criteria for Th-232, the SCM will be used with a single detector. The system will be operated at a target speed of 1 inch per second (inch/sec) with the detector approximately ½ inch from the surface. Survey parameters are established to provide adequate sensitivity to show compliance with the Th-232 limits. For SCM scans for Th-232 in Class 3 areas, the MDCR from Equation 7-5 of the Management Plan (TetraTech 2014a) is:

$$MDCR = d'\sqrt{b_i}(\frac{60}{t})$$

Where: d’ = index of sensitivity (α and β errors [performance criteria])
b_i = number of background counts in scan time interval (counts)
i = count time interval

Therefore:

$$MDCR = 3.28\sqrt{1}\left(\frac{60}{4}\right) = 49.2cpm$$

Where: d’ = 3.28
b_i = 1 count
i = 4 sec (based on a scan speed of 2.5 cm/sec and a detector width of 10 cm.)

and the scan MDC from Equation 7-6 of the Management Plan (TetraTech 2014a) is:

$$Scan\ MDC = \frac{MDCR}{\sqrt{\rho} * \varepsilon_i * \varepsilon_s * \frac{W}{100\ cm^2}}$$

Where: MDCR = as discussed above
P = surveyor efficiency factor
ε_i = instrument efficiency
ε_s = surface efficiency
W = Area of the detector window (cm^2) [Defaults to 100 cm^2 for probes greater than 100 cm^2]

Therefore:

$$Scan\ MDC = \frac{49.2}{\sqrt{1} * 0.5 * 0.25 * \left(\frac{100}{100}\right)} = 393.6\ cpm$$

Where: $p = 1$
$\varepsilon_i = 0.5$
$\varepsilon_s = 0.25$
$W_A = 100\ cm^2$

2.7.2 Beta Scan Measurements

Beta scan surveys will be performed in Building 680. For these beta surveys, the SCM will be the primary instrument. The ROCs in the Class 3 area are Co-60, Sr-90, Cs-137 and U-238. In the Class 3 area, the SCM will be operated on the alpha plus beta plateau at a target speed of 2 inch/sec (5 cm/sec) with the detector at ½ inch from the surface. Survey parameters are established to provide adequate sensitivity to show compliance with the Sr-90 limits. If Sr-90 is found to be in compliance with release criteria, Co-60, Cs-137 and U-238 will also be in compliance. For SCM scans for Sr-90 in Class 3 areas, the MDCR from Equation 7-5 of the Management Plan (TetraTech 2014a) is:

$$MDCR = d'\sqrt{b_i}(\frac{60}{t})$$

Where: d' = index of sensitivity (α and β errors [performance criteria])
b_i = number of background counts in scan time interval (counts)
i = count time interval

Therefore:

$$MDCR = 3.28\sqrt{16.67}\left(\frac{60}{2}\right) = 402\ cpm$$

Where: d' = 3.28
b_i = 16.67 counts (based on 500 cpm background and a 2 sec count interval)
i = 2 sec (based on a scan speed of 5 cm/sec and a detector width of 10 cm.)

and the scan MDC from Equation 7-6 of the Management Plan (TetraTech 2014a) is:

$$Scan\ MDC = \frac{MDCR}{\sqrt{\rho} * \varepsilon_i * \varepsilon_s * \frac{W}{100\ cm^2}}$$

Where: MDCR = as discussed above
P = surveyor efficiency factor
ε_i = instrument efficiency

ε_s = surface efficiency
W = Area of the detector window (cm^2) [Defaults to 100 cm^2 for probes greater than 100 cm^2]

Therefore:

$$Scan\ MDC = \frac{401}{\sqrt{1} * 1.04 * .5 * \left(\frac{100}{100}\right)} = 773\ dpm$$

Where: $p = 1$
$\varepsilon_i = 1.04$
$\varepsilon_s = 0.5$
$W_A = 100\ cm^2$

2.8 ALPHA AND BETA STATIC MEASUREMENTS

Alpha and beta static measurements will be obtained with both the SCM and the Ludlum 43-68 detector coupled to the Ludlum 2221or 2241 rate meter/scaler. The SCM static measurements will supplement the surveys performed in the dynamic or rolling mode when the rolling mode cannot get into areas such as on floors against the wall, or on walls where interferences make rolling surveys impractical. The Ludlum 43-68 detector will be used to obtain fixed measurements at the number of locations identified in Section 2.5.

2.8.1 Alpha Static Measurements

The SCM may be used in the static mode for investigations or to access areas not easily surveyed with the SCM in the dynamic mode. The SCM count time will be 8 seconds, with the detector place on the surface to be surveyed. The MDC calculation for the specified count time from Equation 7-8 of the Management Plan (TetraTech 2014a):

$$MDC = \frac{3 + 3.29\sqrt{R_B T_{S+B}(1 + \frac{T_{S+B}}{T_B})}}{\varepsilon_i \varepsilon_s \frac{W_A}{100\ cm^2} T_{S+B}}$$

Where: R_B = Background count rate (cpm)

T_B = Background counting time (min)

T_{S+B} = Sample counting time (min)

ε_i = Instrument efficiency

ε_s = Surface efficiency

W_A = Active area of the probe window (Defaults to 100 cm^2 for probes greater than 100 cm^2)

Therefore:

$$MDC = \frac{3 + 3.29\sqrt{1 * .133 * \left(1 + \frac{0.133}{0.133}\right)}}{0.5 * 0.25 * \frac{100}{100\,cm^2} * 0.133}$$

MDC = 282.5 dpm

Where:

R_B = 1 cpm

T_B = 8 sec or 0.133 min

T_{S+B} = 8 sec or 0.133 min

ε_i = 0.5

ε_s = 0.25

W_A = 100 cm^2

Direct measurements at predefined locations (See Section 2.5) and investigations will be performed with the Ludlum 43-68 gas proportional detector coupled to a Ludlum 2221 scaler/ratemeter. Static measurements for alpha emissions in Building 680 will require a 2 minute count time for the Ludlum 43-68 based on Th-232. The MDC calculation for the specified count time from Equation 7-8 of the Management Plan (TetraTech 2014a):

$$MDC = \frac{3 + 3.29\sqrt{R_B T_{S+B}\left(1 + \frac{T_{S+B}}{T_B}\right)}}{\varepsilon_i \varepsilon_s \frac{W_A}{100\ cm^2} T_{S+B}}$$

Where: R_B = Background count rate (cpm)

T_B = Background counting time (min)

T_{S+B} = Sample counting time (min)

ε_i = Instrument efficiency

ε_s = Surface efficiency

W_A = Active area of the probe window (Defaults to 100 cm^2 for probes greater than 100 cm^2)

Therefore:

$$MDC = \frac{3 + 3.29\sqrt{1*2*\left(1+\frac{2}{10}\right)}}{0.25*0.25*\frac{100}{100\,cm^2}*2}$$

MDC = 64.8 dpm

Where:

R_B = 1 cpm

T_B = 600 sec or 10 min

T_{S+B} = 120 sec or 2 min

ε_i = 0.25

ε_s = 0.25

W_A = 126 cm^2 (areas greater than 100 cm^2 default to 100 cm^2)

2.8.2 Beta Static Measurements

The MDC for beta static measurements from equation 7-8 of the Basewide Radiological Management Plan (TetraTech 2013) is:

$$MDC = \frac{3 + 3.29\sqrt{R_B T_{S+B}(1 + \frac{T_{S+B}}{T_B})}}{\varepsilon_i \varepsilon_s \frac{W_A}{100\ cm^2} T_{S+B}}$$

Where: R_B = Background count rate (cpm)

T_B = Background counting time (min)

T_{S+B} = Sample counting time (min)

ε_i = Instrument efficiency

ε_s = Surface efficiency

W_A = Active area of the probe window (Defaults to 100 cm^2 for probes greater than 100 cm^2)

Static measurement count times for the beta from the limiting ROC, Sr-90, will be 8 seconds for the SCM and 30 seconds for the Ludlum 43-68 with the 2221 or 2241 scaler/ratemeter. For the SCM surveying for Sr-90, the MDC, equation 7-8 from the Basewide Radiological Management Plan (TetraTech 2014a) becomes:

$$MDC = \frac{3 + 3.29\sqrt{500 * .133 * (1 + \frac{.133}{.133})}}{1.04 * 0.5 * \left(\frac{100}{100}\right) * .133} = 592\ dpm$$

Where: R_b = 500 cpm
T_{s+b} = 8 sec. or .133 min
T_b = 8 sec. or .133 min
ε_i = 1.04
ε_s = 0.5
W_A = 100 cm^2

For the Ludlum 43-68 surveying for Sr-90, the equation becomes:

$$MDC = \frac{3 + 3.29\sqrt{200 * .5 * (1 + \frac{.5}{.5})}}{.52 * .52 * \left(\frac{100}{100}\right) * .5} = 366\ dpm$$

Where: R_b = 200 cpm
T_{s+b} = 30 sec. or 0.5 min
T_b = 30 sec. or 0.5 min
ε_i = 0.52
ε_s = 0.5
W_A = 100 cm^2

2.9 Gamma Walkover Surveys

Gamma walkover surveys will be conducted in each survey unit with a "2" by "2" sodium iodide detector and a Ludlum 2241 scaler/ratemeter. Gamma readings will be obtained in accordance with Section 8.2.2 of the Basewide Radiological Management Plan (TetraTech 2014a). Surveys will be conducted in accordance with procedure SUR-022, *Gamma Walkover Surveys*.

2.10 Removable Contamination Surveys

Prior to the conduct of scanning surveys, removable contamination will be assessed by wiping the survey unit with a Masslin cloth on a suspect area and monitoring the swiped cloth with a Ludlum 43-68 detector coupled to a Ludlum 2221 scaler/ratemeter. Since both alpha and beta emitting nuclides are of concern, the Masslin cloth will be surveyed by detectors operating on the alpha plateau, then the alpha plus beta plateau. Areas in which the first wipe of the Masslin cloth indicates any increase in activity will be re-wiped with the Masslin cloth to determine the specific area that contains removable contamination. Swipe surveys using disc swipes will be conducted at any area indicating activity above background.

Swipe surveys will also be conducted in at least one location within each 1,000 ft^2 in a Class 3 survey unit, at each floor and sink drain and at each of the systematic data collection locations. All swipe surveys will be counted onsite using a Ludlum 2929 detector which records both alpha and beta activity simultaneously. Wet swipe surveys will be performed at each of the systematic data collection locations, at least one location within each 1,000 ft^2 of each survey unit and at each floor or sink drain. Wet swipes will be counted off site with liquid scintillation counting to determine the presence of H-3. Swipe surveys will be performed and documented in accordance with SOP-006, *Radiation and Contamination Surveys*.

2.11 Media Samples

Samples will be collected if sediment is found in sumps, floor drains, and sink drains to support evaluation of compliance with release criteria and to determine specific nuclides as necessary. Sampling may also be performed as an integral part of investigations to determine the cause of elevated measurements. Samples will be collected in accordance with SOP-009, *Sampling Procedures for Radiological Surveys* and submitted to an off-site laboratory for radiological analysis. One sediment sample per drain will be collected if sufficient sediment is present. Analysis of results will be evaluated against soil criteria identified in Table 2.

Media samples will also be obtained at any accessible building outfall locations that would contain liquid runoff from Building 680.

3.0 SITE RESTORATION

Site restoration work is not required at the conclusion of surveying in Building 680.

4.0 BUILDING 680 REPORT

Results of the survey that demonstrate that no single measurement indicating activity greater than the release criteria, and the resultant risk based dose as calculated, will be presented in a survey report. Any conclusion other than a recommendation for unrestricted release will be presented in a Characterization Report.

5.0 QUALITY CONTROL

The data quality objectives for the survey are provided in Table 3.

Definable features of work (DFW) establish the measures required to verify both the quality of work performed and compliance with project requirements. The DFW for this task is radiological surveys. Description of this DFW and the associated phases of quality control are presented in Table 4.

6.0 ENVIRONMENTAL PROTECTION

Environmental protection requirements are addressed in the Management Plan (TetraTech 2014a).

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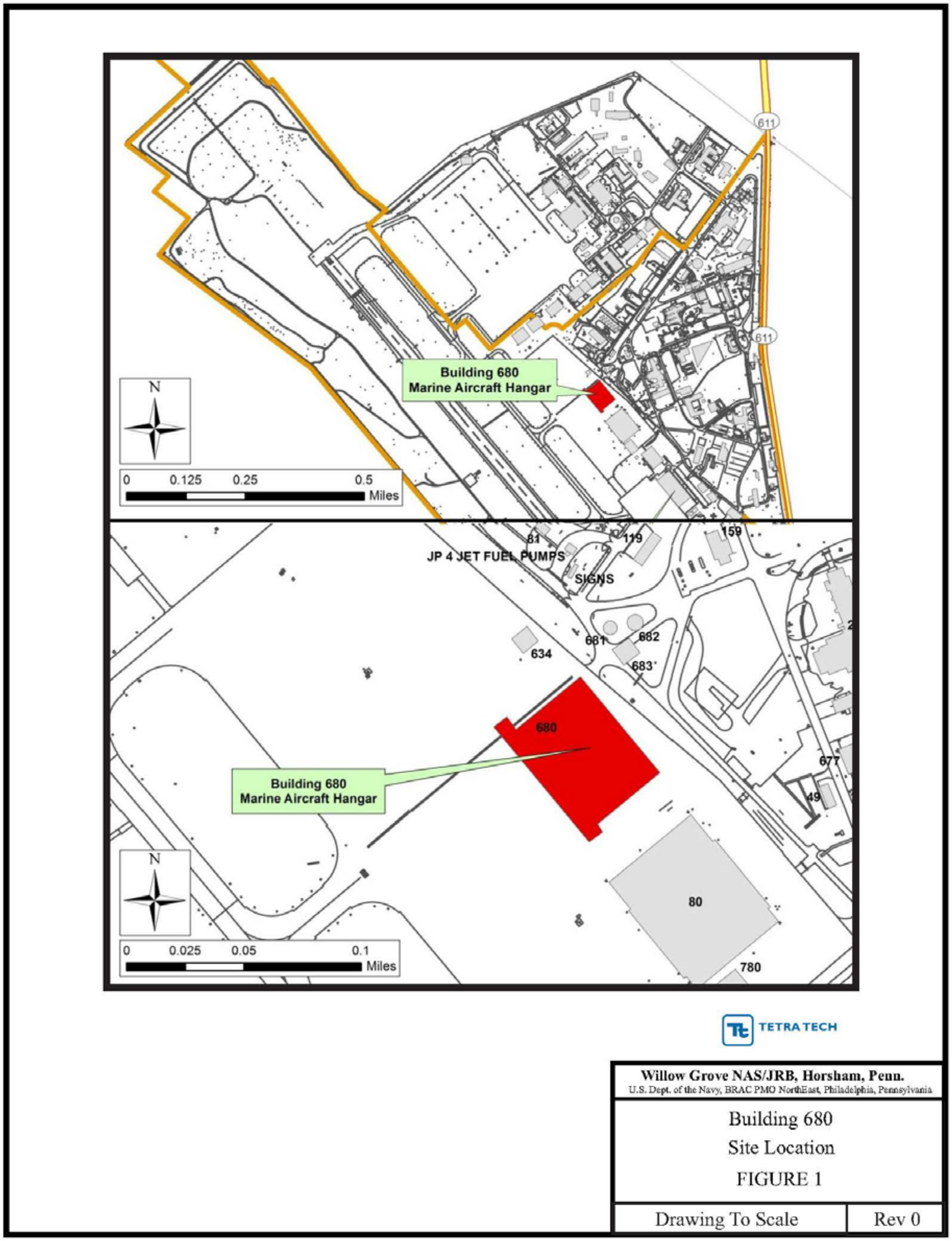
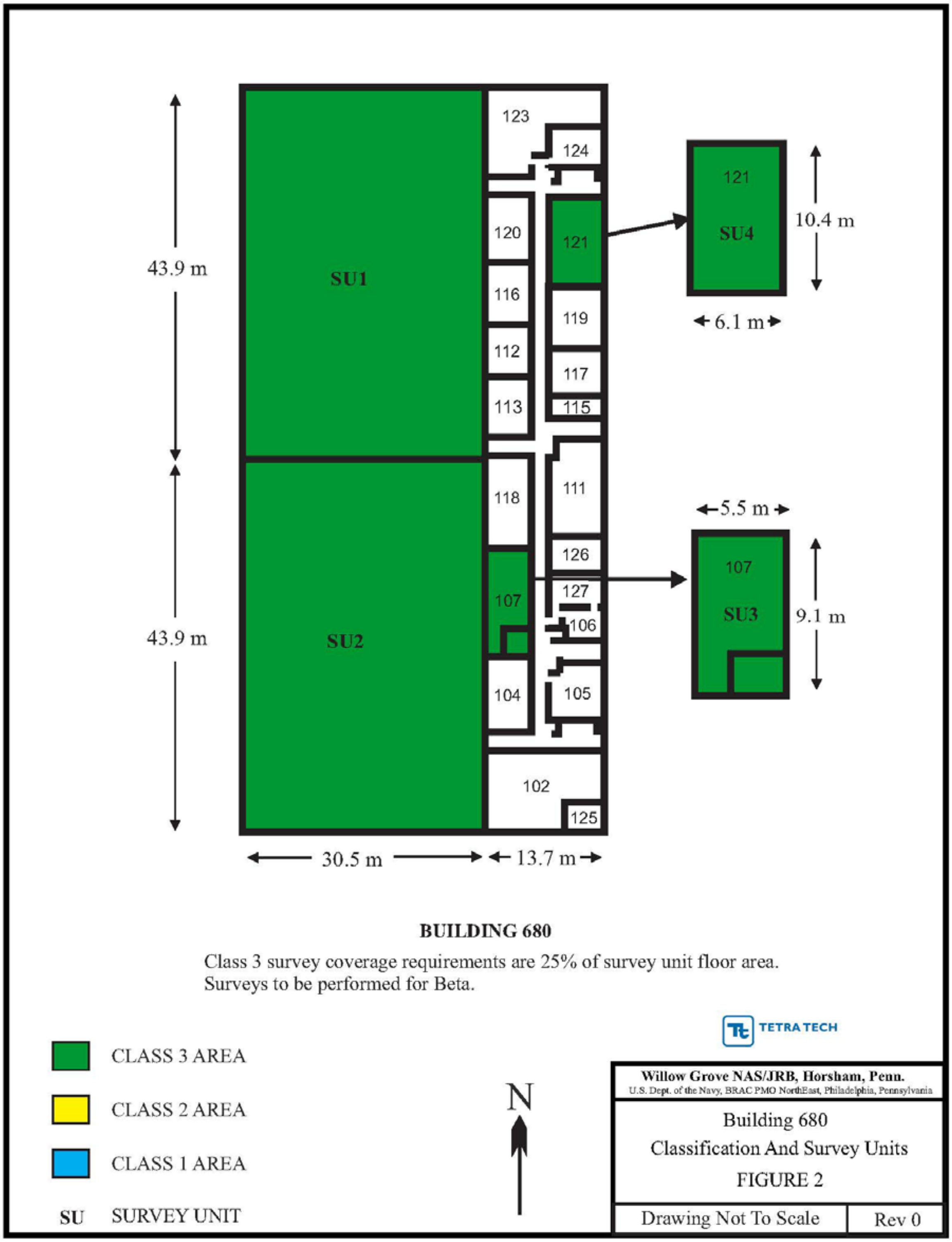
FIGURES



611
Building 680
Marine Aircraft Hangar
N
0 0.125 0.25 0.5
Miles
81
119
159
JP 4 JET FUEL PUMPS
SIGNS
681
682
634
683
680
677
49
80
780
0 0.025 0.05 0.1
TETRA TECH
Willow Grove NAS/JRB, Horsham, Penn.
U.S. Dept. of the Navy, BRAC PMO NorthEast, Philadelphia, Pennsylvania
Building 680
Site Location
FIGURE 1
Drawing To Scale
Rev 0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SU1
SU2
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SU4
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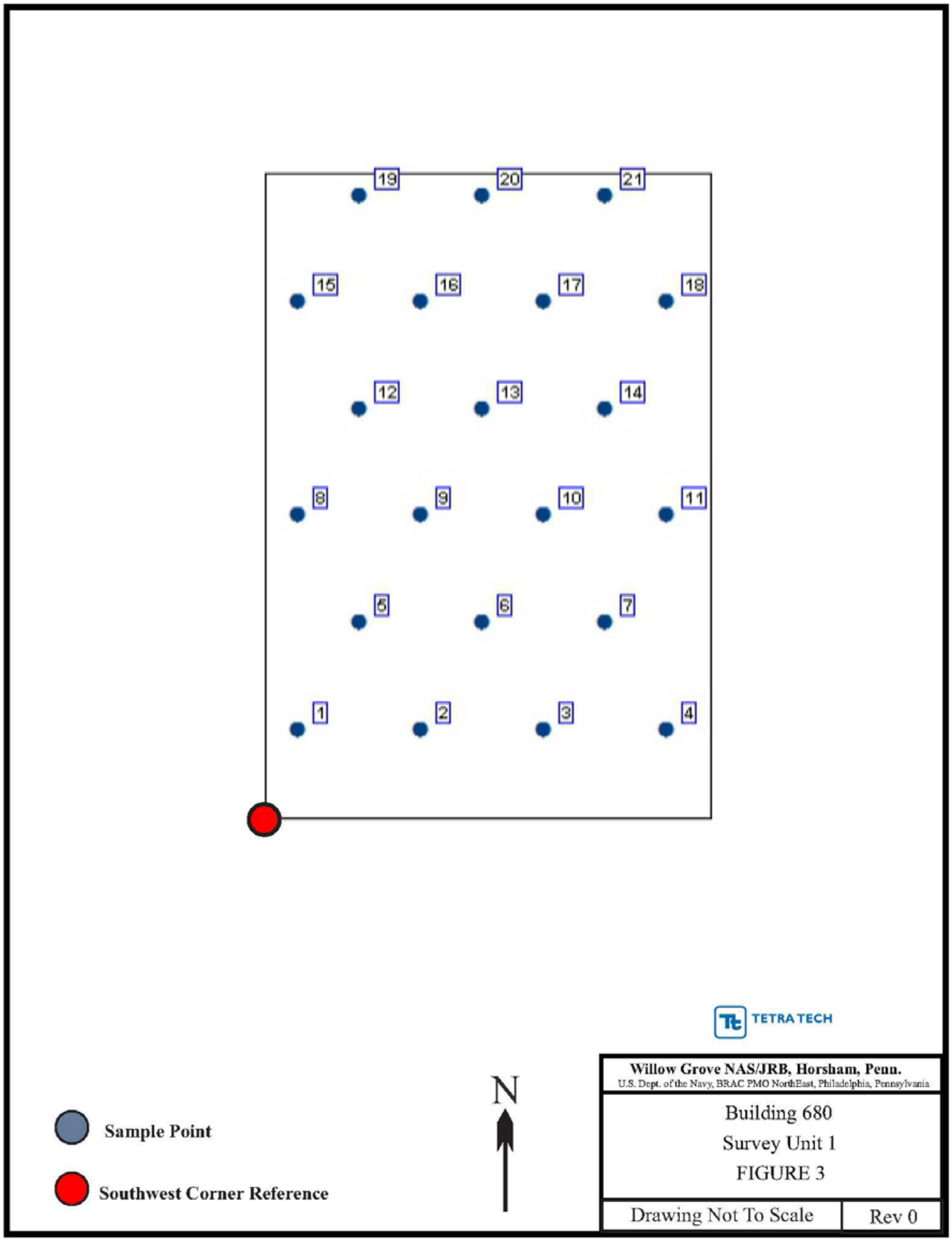
6.1 m
5.5 m
107
SU3
9.1 m
43.9 m
43.9 m
30.5 m
13.7 m
BUILDING 680
Class 3 survey coverage requirements are 25% of survey unit floor area.
Surveys to be performed for Beta.
CLASS 3 AREA
CLASS 2 AREA
CLASS 1 AREA
SU SURVEY UNIT
N
TETRA TECH
Willow Grove NAS/JRB, Horsham, Penn.
U.S. Dept. of the Navy, BRAC PMO NorthEast, Philadelphia, Pennsylvania
Building 680
Classification And Survey Units
FIGURE 2
Drawing Not To Scale
Rev 0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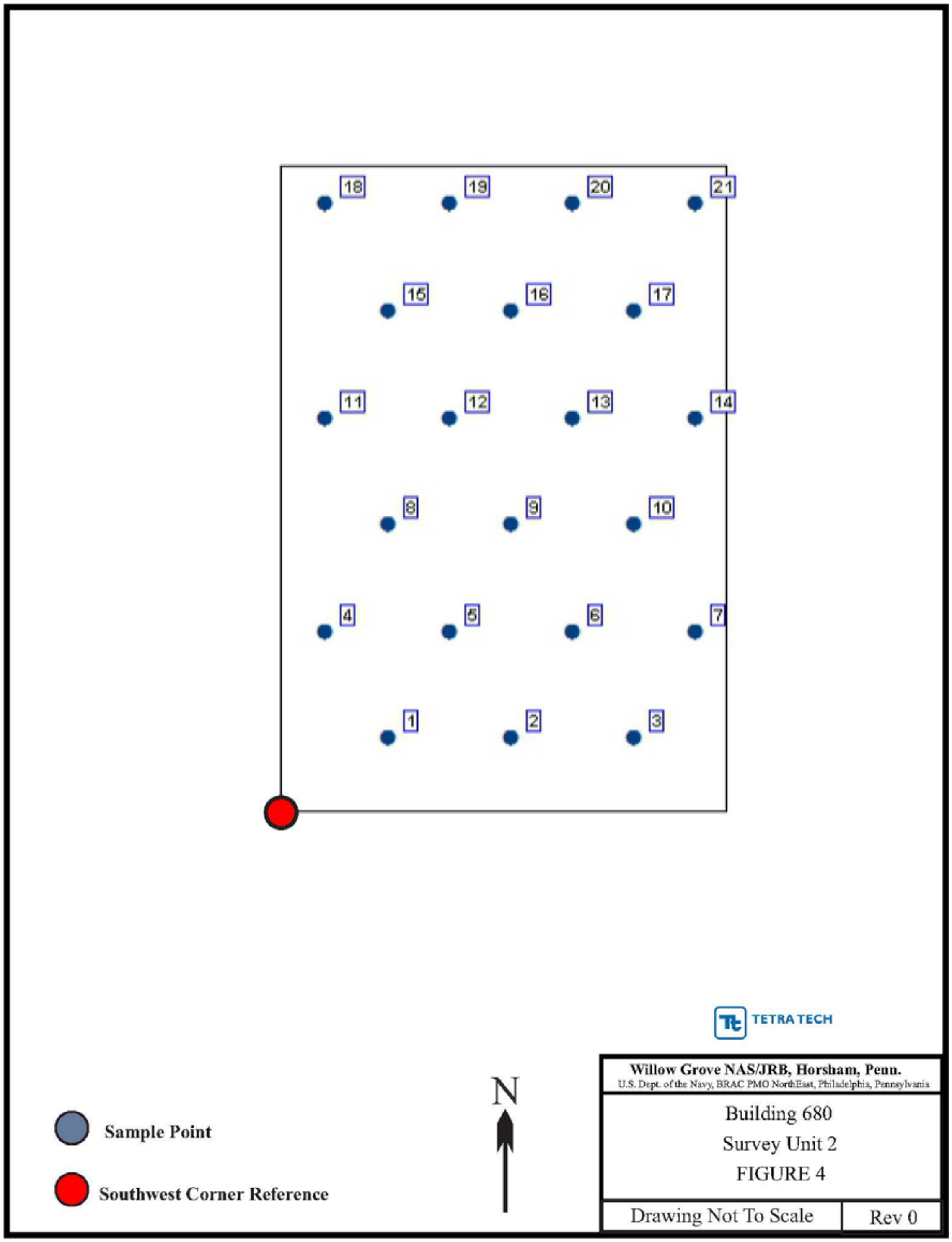
TETRA TECH
Willow Grove NAS/JRB, Horsham, Penn.
U.S. Dept. of the Navy, BRAC PMO NorthEast, Philadelphia, Pennsylvania
Building 680
Survey Unit 1
FIGURE 3
Drawing Not To Scale
Rev 0
N
Sample Point
Southwest Corner Reference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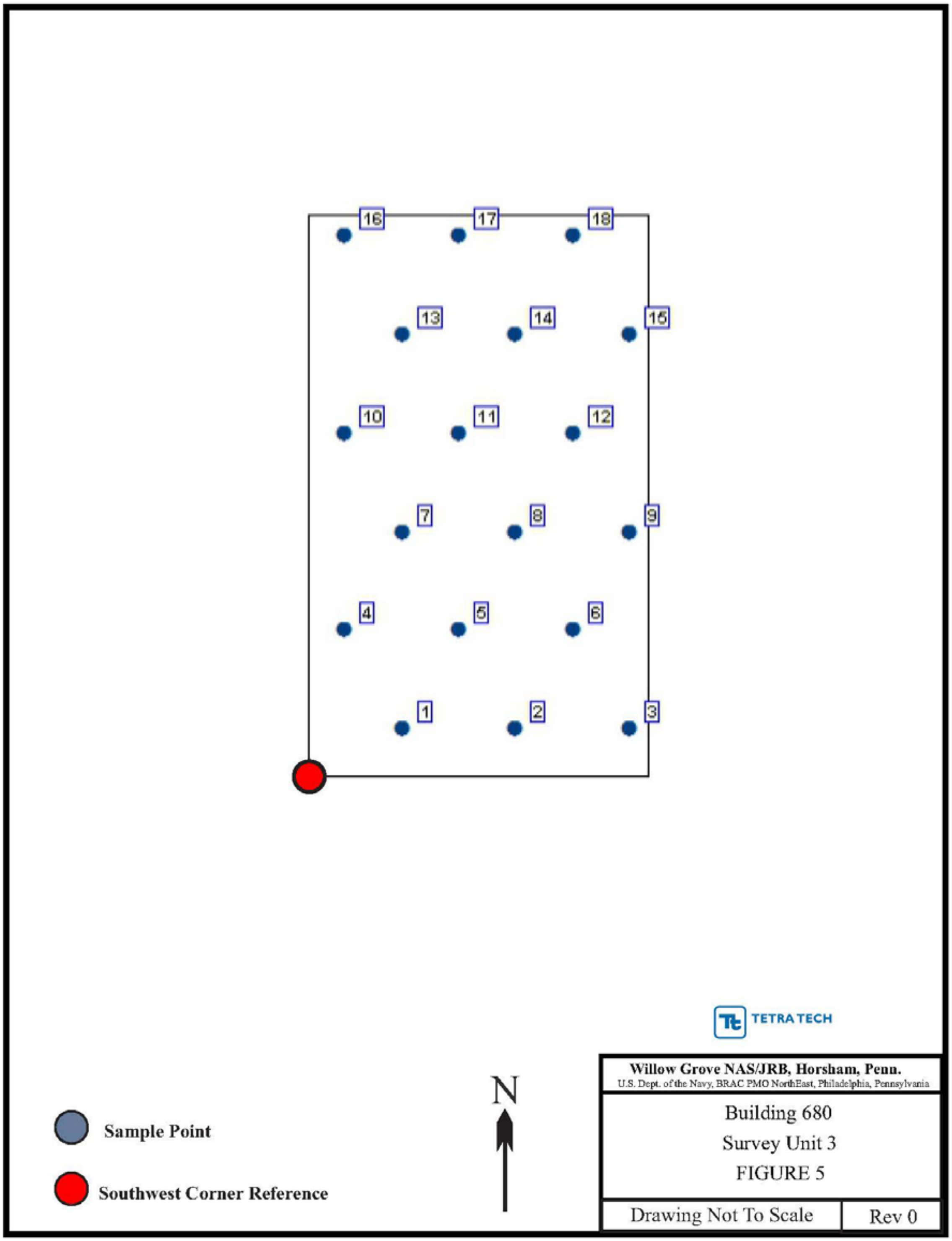
TETRA TECH
Willow Grove NAS/JRB, Horsham, Penn.
U.S. Dept. of the Navy, BRAC PMO NorthEast, Philadelphia, Pennsylvania
Building 680
Survey Unit 2
FIGURE 4
Drawing Not To Scale
Rev 0
N
Sample Point
Southwest Corner Reference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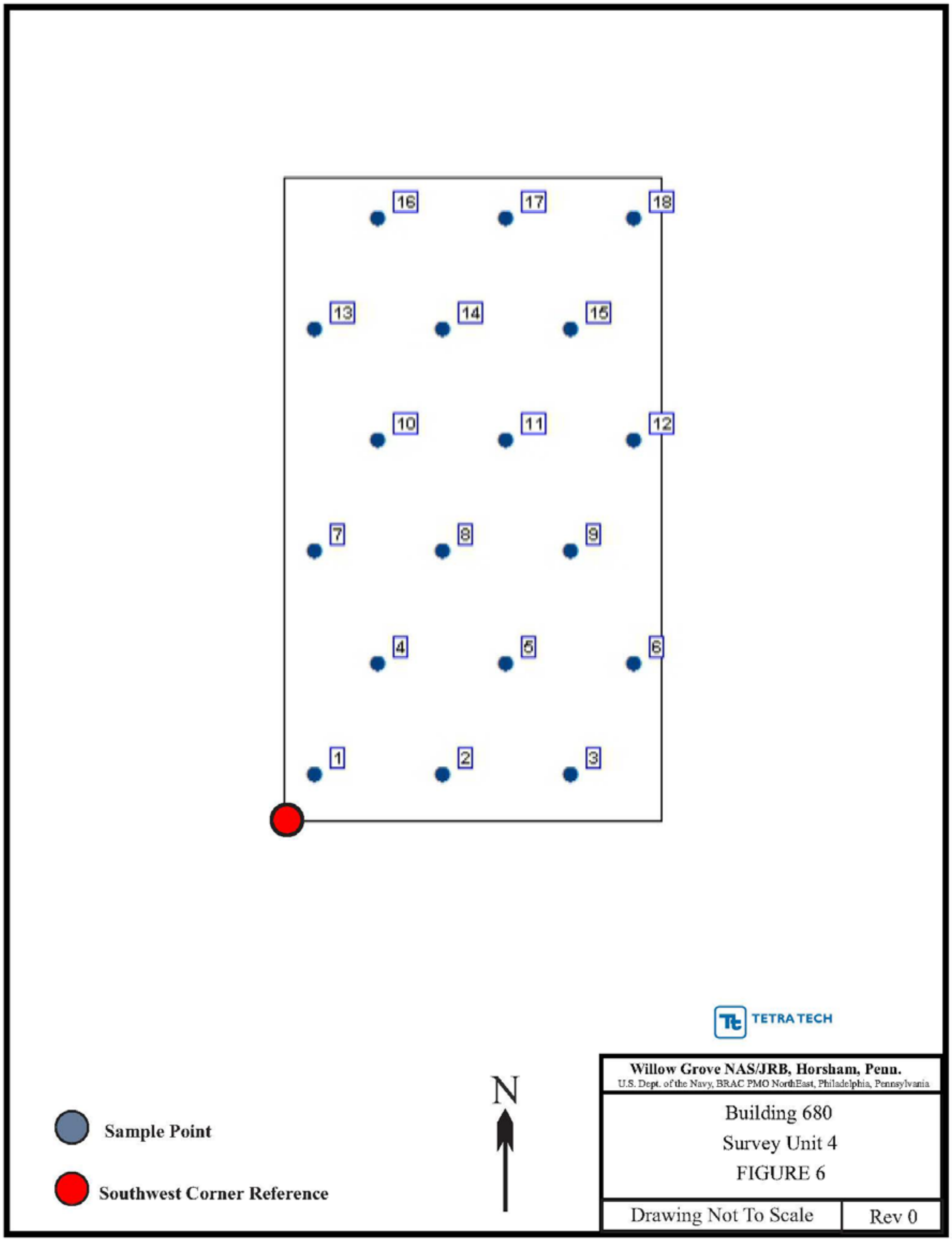
TETRA TECH
Willow Grove NAS/JRB, Horsham, Penn.
U.S. Dept. of the Navy, BRAC PMO NorthEast, Philadelphia, Pennsylvania
Building 680
Survey Unit 3
FIGURE 5
Drawing Not To Scale
Rev 0
N
Sample Point
Southwest Corner Reference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TETRA TECH
Willow Grove NAS/JRB, Horsham, Penn.
U.S. Dept. of the Navy, BRAC PMO NorthEast, Philadelphia, Pennsylvania
Building 680
Survey Unit 4
FIGURE 6
Drawing Not To Scale
Rev 0
N
Sample Point
Southwest Corner Reference

TABLES

TABLE 1 BUILDING 680 APPLICABLE STANDARD OPERATING PROCEDURES

Procedure	Title	Rev
SOP 002	Radiation Work Permits	0
SOP 004	Project Dosimetry	0
SOP 006	Radiation and Contamination Surveys	0
SOP 007	Preparation of Portable Radiation and Contamination Survey Meters for Field Use	0
SOP 008	Air Sampling and Sample Analysis	0
SOP 009	Sampling Procedures for Radiological Surveys	0
SOP 010	RCA Posting and Access Control	0
SOP 011	Control of Radioactive Materials	0
SOP 012	Release of Materials and Equipment	0
SOP 016	Decontamination of Equipment and Tools	0
SOP 022	Radiological Clothing Selection, Monitoring and Decontamination	0
SOP 023	Source Control	0
SOP 024	Occurrence Reporting	0
SUR 022	Gamma Walkover Surveys	0
RP-OP-017	Operation of the Ludlum Model 2929 Dual Scaler	0
RP-OP-025	Operation of the Ludlum Model 2221	0
RP-OP-026	Operation of the Ludlum Model 19	0
SCM-OPS-01	Position Sensitive Proportional Counters Purging	0
SCM-OPS-02	Position Sensitive Proportional Counters Plateau Determination	0
SCM-OPS-03	Position Sensitive Proportional Counters Position Calibration	1
SCM-OPS-04	Encoder Calibration	0
SCM-OPS-05	Position Sensitive Proportional Counters Efficiency Calibration	0
SCM-OPS-06	Position Sensitive Proportional Counters Quality Assurance	1
SCM-SETUP-01	Position Sensitive Proportional Counters Repair	0
SCM-SETUP-02	Hardware Setup	0
SCM-SETUP-03	Quality Assurance Testing of SCM	0

TABLE 2 BUILDING 680 PRIMARY RADIATION PROPERTIES AND RELEASE CRITERIA FOR RADIONUCLIDES OF CONCERN

Radionuclide	Primary Radiation Properties		Release Criteria[a]				
			Materials & Equipment		Building Surfaces		Soil[b]
	Half-Life	Type	Total Surface Activity	Removable Activity	Total Surface Activity	Removable Activity	Activity (pCi/g)
H-3	12.26 Years	beta	5,000	1,000	5,000	1,000	66
Co-60	5.27 Years	Beta	5,000	1,000	5,000	1,000	2.28
Cs-137	30.00 Years	Beta	5,000	1,000	5,000	1,000	6.6
Sr-90	3.01E01 Years	Beta	1,000	200	1,000	200	1.02
Th-232	1.41E10 Years	Alpha	1,000	200	1,000	200	0.66
U-238	4.51E09 years	Alpha & Beta	5,000	1,000	5,000	1,000	8.4

Notes:

a Units are disintegrations per minute per 100 square centimeters, unless otherwise specified.
b Criteria is above background for those radionuclides found in background soils.

Co-60 Cobalt 60
Cs-137 Cesium 137
H-3 Tritium
Sr-90 Strontium 90
Th-232 Thorium 232
U-238 Uranium 238

Source: TetraTech 2014a. Basewide Radiological Management Plan, Naval Air Station Joint Reserve Base Willow Grove, Willow Grove, Pennsylvania.

TABLE 3 SUMMARY OF DATA QUALITY OBJECTIVES

STEP 1 Statement of Problem	STEP 2 Decisions	STEP 3 Inputs to the Decisions	STEP 4 Boundaries of Study	STEP 5 Decision Rules	STEP 6 Limits on Decision Errors	STEP 7 Optimizing the Sampling Design
Building 680 is listed in the HRA as an area impacted by radiological activities. The isotopes of concern are H-3, Co-60,Sr-90, Cs-137, Th-232 and U-238. It must be determined if the site-specific release criteria for these isotopes have been met or if remediation or further survey is warranted.	The primary use of the data expected to result from completion of this TSP is to support the Scoping Survey of Building 680. Therefore the decision to be made can be stated as "Do the results of the survey indicate activity above background or meet the release criteria?"	Radiological surveys required to support the Final Status Survey of Building 680 will include: • 25 percent scan surveys of the Class 3 area • A minimum of 17 systematic static measurements will be performed in the Class 3 area • One swipe per 1,000 square feet • One sediment sample will be collected from each drain if available. • One swipe at each systematic sample location • One wet swipe per 1,000 square feet • One wet swipe at each systematic sample location	The lateral and vertical spatial boundaries for this survey effort are confined to the hangar bay and to rooms 107 and 121 of Building 680.	If the concentration of radioactivity on building surfaces, paved areas, or in sediment samples is less than the release criteria, then no further measurements are required. If the results of the survey exceed the release criteria, then the building will be investigated further.	Limits on decision errors are set at 5 percent as specified in the Management Plan (TetraTech 2014a).	Operational details for the radiological survey process have been developed. The theoretical assumptions are based on guidelines contained in MARSSIM (NRC 2000). Specific assumptions regarding types of radiation measurements, instrument detection capabilities, quantities and locations of data to be collected, and investigation levels are contained in this TSP and the Management Plan (TetraTech 2014a)

Notes:

Co-60	Cobalt 60
Cs-137	Cesium 137
H-3	Tritium
HRA	Historical Radiological Assessment
MARSSIM	Multi-Agency Radiation Survey and Site Investigation Manual
NRC	Nuclear Regulatory Commission
Sr-90	Strontium 90
TSP	Task Specific Plan
Th-232	Thorium 232
U-238	Uranium 238

TABLE 4 DEFINABLE FEATURES OF WORK FOR RADIOLOGICAL SURVEYS

ACTIVITY	PREPARATORY (Prior to initiating survey activity)	DONE	INITIAL (At onset of survey activities)	DONE	FOLLOW-UP (Ongoing during survey activities)	DONE
Radiological Surveys	• Verify that an approved TSP is in place. • Verify that the Remedial Project Manager and the Caretaker Site Office are notified about mobilization. • Verify that an approved Radiation Work Permit, if required, is available and has been read and signed by assigned personnel. • Verify that the Management Plan, HASP and TSP, have been reviewed. • Verify that personnel assigned are trained and qualified. • Verify that personnel have been given an emergency notification procedure. • Verify that workers assigned dosimeter have completed NRC Form 4. • Verify that relevant SOPs are available and have been reviewed for equipment to be used. • Verify that equipment is on site and in working order (initial daily check).		• Verify that radiological instruments are as specified in the Management Plan (TetraTech 2014a) and TSP. • Inspect Training Records. • Verify that reference area measurements have been obtained in accordance with the Management Plan (TetraTech 2014a). • Verify that daily checks were performed on all survey instruments. • Verify that instrument calibration and setup are current. • Verify that required dosimeter is being worn. • Verify that field logbooks and proper forms are in use. • Verify that samples and measurements are being collected in accordance with the TSP, Management Plan and applicable SOPs. • Verify the sample handling is in accordance with the Management Plan (TetraTech 2014a) and applicable SOPs.		• Verify that the site is properly posted and secured. • Conduct ongoing inspections of material and equipment. • Verify that daily instrument checks were obtained and documented. • Verify that survey results were documented. • Inspect chain-of-custody and survey logs for completeness. • Verify that survey activities conform to the TSP. • Verify that survey instruments are recalibrated after repairs or modifications.	

Notes:

HASP Health and Safety Plan
NRC Nuclear Regulatory Commission
SOP Standard Operating Procedure
TSP Task Specific Plan

ATTACHMENT 1

SURFACE CONTAMINATION MONITOR/SURVEY INFORMATION MANAGEMENT SYSTEM
COMPLIANCE WITH RASO GUIDANCE DOCUMENT
CONDUCTING ALPHA SCANS FOR RADIUM

MILLENNIUM SERVICES, INC.

Leading the way…

Surface Contamination Monitor/Survey Information Management System
Compliance with RASO Guidance Document
Conducting Alpha Scans for Radium

May 2014

Prepared By:

Original Signed By
Richard W. Dubiel, CHP

Surface Contamination Monitor/Survey Information Management System Compliance with RASO Guidance Document Conducting Alpha Scans for Radium

RASO has issued a guidance document for conducting alpha scans for radium-226 (RASO 2013). The document follows the protocols established in MARSSIM (NRC 2000). Since Ra-226 is an alpha emitter that is assigned a low release criterion by Navy standards, the detection process must rely on Probability of Detection Theory to determine the ability of an instrument to detect elevated areas of alpha activity during the scanning process. Specifically, the Navy has imposed acceptance criteria of 100 dpm/ 100 cm^2. Because of the low emission rate at this level of activity of Ra-226, the recommended process is to slowly scan at rates no greater than ½ inch per second and listen for audible clicks. Typically more than one click within the detector area will indicate the potential that Ra-226 at the release limit is present. The area must be marked or immediately investigated with longer, static counts. The probability of detecting 2 or more counts in a scan interval is defined by equations found in Appendix J to MARSSIM (NRC 2000) and provided in the RASO guidance (RASO 2013).

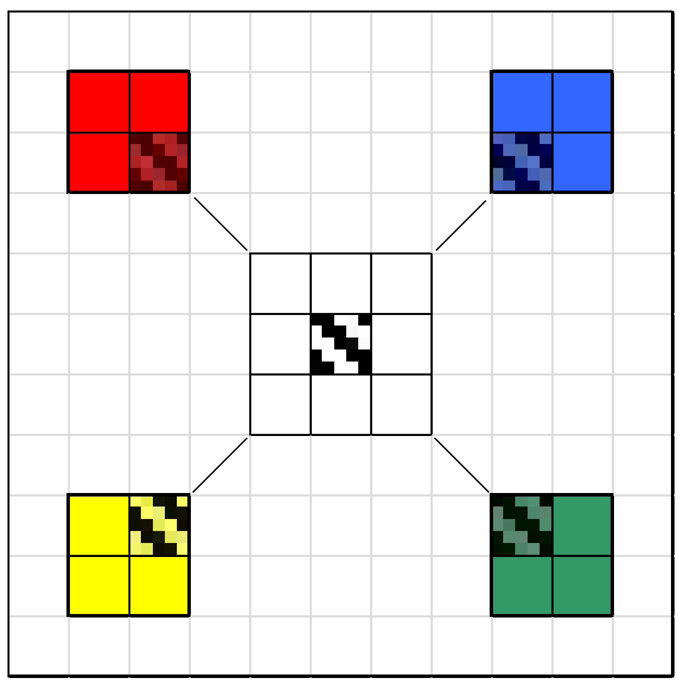
RASO guidance (RASO 2013) recommends that equipment and scan speed be chosen such that there is a 90% probability of detecting a 100 dpm/100 cm^2 source. A minimum probability of 68% detection is included. Inherent in the guidance is that false positives from background in materials such as concrete or asphalt will occur a significant percent of the time and can be predicted by Poisson statistics. The Surface Contamination Monitor (SCM) and Survey Information Management System (SIMS) are capable of scanning surveys that meet the detection probability requirements and significantly reduce the number of false positives from material background that subsequently require investigation.

The SCM is an automated system utilizing a DC motor drive to control scan speed, a precision wheel encoder to measure relative location, large area position sensitive detectors with offsets to maintain constant detector to surface distance, and a computer to record count rate data and system speed. The large area detectors are Position Sensitive Proportional Counters (PSPC) with lengths up to 180 cm, and width of 12 cm. The SCM utilizes a gas flow position sensitive proportional counter (PSPC). The PSPC functions as any gas flow proportional counter, using P-10 as the counting gas. As in any proportional counter, voltage plateaus are established for the detection of alpha or alpha plus beta particles. High voltage appropriate for the type of particles to be detected is applied to the single anode wire which runs the length of the detector. The SCM computer compares the pulse heights of pulses sensed at each end of the anode wire and establishes the location on the anode wire where the pulsed was sensed. Although the available resolution is greater than 2,000 locations on the anode wire, the SCM computer will “bin” the data in 5 centimeters (cm) wide increments along the length of the wire.

The SCM can be operated in both a dynamic or “rolling” mode or a static or “corner” mode. In the dynamic mode, the system uses a direct current powered drive motor affixed to a cart which contains all electronics and computer hardware, and to which a detector (or two) is mounted. The SCM's design focuses on the elimination of human errors associated with performing surveys of large areas. The system is designed such that surveys are performed at constant speed, the detector maintained at a set distance from the surface being surveyed, and survey data recorded automatically. In the dynamic mode, a precision wheel encoder is mounted to the cart axle to determine distance traveled by the cart. The encoder can measure to a small fraction of a centimeter and is used to trigger the computer to capture data for every 5 cm of travel of the SCM cart. The result is count data (counts) for every 5 cm "bin" and every 5 cm of travel, or a matrix of 25 cm^2 "pixels" of data. In the static mode, a preset time is applied to the collection of data from a stationary detector. Data is binned in a manner similar to the dynamic mode.

Data is transferred from the SCM to a processing station containing the Survey Information Management System (SIMS) software via removable media. SIMS software is used to "stitch" the individual strips of data to create a single survey of an entire area. The data collected in 25 cm^2 "pixels" is summed with adjacent "pixels" in a manner that will result in the evaluation of every possible 100 cm^2 area. When determining activity, each 25 cm^2 "pixel" is 25 percent of four overlapping 100 cm^2 areas. This process ensures that small areas of activity above limits are not missed through grid registration errors.

Each 25 cm^2 pixel is part of 4 overlapping 100 cm^2 areas



Performance of alpha scan surveys includes the use of a second or "recount" detector hard mounted at a set distance behind the primary detector. The recount detector records a second set of data for the same area surveyed by the primary detector, with both data sets filed on the SCM computer and subsequently transferred to SIMS. The recount survey acts as an automated "investigation" of all 100 cm^2 areas surveyed by the primary detector. The calculations below are designed to show that SCM/SIMS is capable of meeting the probability of detection guidance of the RASO guidance (RASO 2013) and greatly reducing the number of false positives due to material background.

Calculations

Efficiency values have been determined using a NIST traceable thorium 230 (Th-230) source. The source is a 5 mm diameter source, more like a point source than a distributed source. The physical size of the source provides a better approximation of the size that would be represented by a 100 dpm Ra-226 spot. The specific activity of Ra-226 is 1 Curie per gram, therefore 100 dpm would be 4.5×10^{-11} grams of Ra-226.

Due to the physical size of the source, the data accumulation in 25 cm^2 "pixels", and the summing of 4 adjacent "pixels" as described above creating a 100 cm^2 area data entry, the count rate from the NIST traceable source would be doubled. The result is an efficiency far greater than other proportional counters. Demonstrated 2π detector efficiencies (ε_i), exceed 100%. Surface efficiency (ε_s) is 0.25 as stated in the RASO guidance document (RASO 2013).

Alpha background values from concrete and asphalt surfaces vary greatly based on materials from various regions of the US, various sources within a specific area, and even locations within a quarry. Background can also be affected by radon progeny on the surface. Experience has shown that typical alpha backgrounds measured by the SCM are less than 1 cpm per 100 cm^2.

Probability of detection equations are found in the RASO guidance (RASO 2013) and MARSSIM (NRC 2000), Appendix J. The SCM will identify a positive indication based on 2 or more counts in a 100 cm^2 area. The equation applied to the SCM survey is:

Equation 1

$$P(n \geq 2) = \; 1 - e^{\frac{-(GE+B)t}{60}} \left[1 + \frac{(GE + B)t}{60}\right]$$

Where: P = Probability of Detecting counts (n)
B = background count rate (cpm)
G = hot spot activity (dpm)
E = total efficiency ($\varepsilon_i \times \varepsilon_s$)
ε_i= detector efficiency (2π)
ε_s= surface efficiency (0.25)
t = resident time (sec.)

The following parameters are used to calculate the probability of getting 2 or more counts in a 100 cm^2 area from a 100 dpm hot spot on a single PSPC detector scanning at ½ inch per second:

> B = 1 cpm
> G = 100 dpm
> E = 0.25
> ε_i = 1.00
> ε_s = 0.25
> t = 8 sec (two 5 cm long pixels, 1.25 cm/sec scan speed)

SIMS computer analysis tools allow for the evaluation of both the primary and recount as separate surveys and evaluation of the two surveys in a coincidence mode. Each 100 cm^2 area surveyed by both detectors is evaluated against a threshold value of 2 or more counts. If both detectors indicate greater than 2 or more counts, the calculated activity from each detector is averaged and identified in the coincidence count display and data table. If either primary or recount detector indicates less than 2 counts, a null value is identified in the coincidence display and data table.

Since the recount detector is hard mounted to the primary detector, the scan speed will be identical. PSPC efficiencies are very similar and all tested have exhibited 2π efficiencies of greater than 1.00. The probability of detection will be the same on both detectors. Therefore, the probability of getting 2 or more counts in a 100 cm^2 area from a 100 dpm hot spot on both detectors is the square of the probability from a single detector.

In order to calculate the false positive rate, i.e. the probability of identifying "contamination" above a certain value, while only background is present, the same formula can be used. Setting the hot spot value to zero will provide the probability of getting 2 or more counts in a 100 cm^2 area from 1 cpm background on a single PSPC detector scanning at ½ inch per second. Again, the probability of getting 2 or more counts in a 100 cm^2 area from 1 cpm background on both detectors is the square of the probability from a single detector.

When used in the static mode, the detector is placed on the surface with a computer controlled preset counting time. A single detector is used with the detector remaining stationary for 2 data acquisitions. A full survey in the static mode will result in many “strips” of data. SIMS processing will create two complete surveys, using alternating data strips for the primary and recount surveys. Coincidence analysis is applied in the same manner as described above. The counting time is set at 8 seconds for each acquisition and the instrument efficiency is similar to that determined for the dynamic mode. Therefore probability of detection calculations will be the same for both the dynamic and static modes of operation.

The results of applying both the 100 dpm/100 cm^2 hot spot and the zero hot spot and 1 cpm background to the probability of detection equation are as follows:

SCM Probability of Detection for Surface Alpha Activity		
G Hot Spot Value	$P(n \geq 2)$ Single PSPC Detector	$P(n \geq 2)$ Primary and Recount PSPCs
100 dpm/100 cm^2	0.861 (86%)	0.741 (74%)
0	0.008	6.62E-05

Conclusion

The SCM/SIMS process uses an automated data collection process to minimize human errors associated with surveys for low activity alpha emitting radionuclides. Using a second detector, in recount mode of data collection, provides an ongoing means of investigation for small count rates that may be a result of surface background. The SCM/SIMS system provides two separate surveys of the same area, allowing for spatial coincidence analysis of the data. The SCM/SIMS system is sufficiently sensitive to meet the RASO guidance for alpha scanning for radium-226 while providing a computerized analysis of the results from the two surveys to greatly reduce the number of investigations required from natural activity that may be on or in the surface material.

REFERENCES

NRC (Nuclear Regulatory Commission). 2000. NUREG-1575, *Multi-Agency Radiation Survey and Site Investigation Manual* (MARSSIM), Rev. 1. August.

RASO (Radiological Affairs Support Office). 2013. *RASO Guidance Document – Conducting Alpha Scans for Radium, Final*. December